Savannah River Site
Solid Waste Management Department
Consolidated Incinerator Facility
Operator Training Program

STANDBY DIESEL GENERATOR SYSTEM (U)

Study Guide

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Revision 00

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Training Manager / Date

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Engineering Manager / Date

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REVISION LOG

REV.	AFFECTED SECTION(S)	SUMMARY OF CHANGE
02	All	Format Change And New Material

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REFERENCES

1. 261-AOP-ELNA-01, *Loss of 13.8 kV Electric Power (U),* Rev 2

2. 261-OOR-01, *Outside Operator Rounds (U),* Rev. 3

3 261-ROR-01 R S, *Regulatory Operator Rounds (U),* Rev. 4

4. 261-SOP-EEP-01 R, *Standby Diesel Generator No.1 Operation (U),* Rev.7

5. 261-SOP-EEP-02 R, *Standby Diesel Generator No.2 Operation (U),* Rev.7

6. 261-SOP-ELNA-01, *13.8 kV/480 Volt Substation (U),* Rev. 2

7. 261-SOP-ELNH-01, *480 Volt Power Electrical (U),* Rev. 4

8. 261-SUR-EEP-01, *Standby Diesel Generator No. 1 Monthly (U),* Rev. 2

9. 261-SUR-EEP-02, *Standby Diesel Generator No. 2 Monthly (U),* Rev. 2

10. 261-SUR-EEP-03, *Standby Diesel Generator No. 1 Weekly (U),* Rev. 3

11. 261-SUR-EEP-04, *Standby Diesel Generator No. 2 Weekly (U),* Rev. 3

12. 261-SUR-HTTR-01, *Consolidated Incineration Facility Freeze Protection (U),* Rev. 0

13. ARP-EEP5402EA, *Trouble D/G #1 Alarm,* Rev. 0

14. ARP-EEP5406EA, *Trouble D/G #2 Alarm,* Rev. 0

15. BPF 216848 Vendor Manual Rev. DE-1, 6-15-95

16. Drawing W830395, *Savannah River Site, Bldg. 261-H Area 200-H Consolidated Incineration Fac. Single Line Dia. 480V Substa. Electrical. (U)* Rev 3

17. Drawing W830405, *Savannah River Site, Bldg. 261-H Area 200-H Consolidated Incineration Fac. Single Line Diagram MCC 7 Electrical (U)* Rev 7

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19. Drawing W833023, *Savannah River Site, Building 261-H Area 200-H Diesel Generator Set Process PPG & Instr Diagram Process & Instruments (U)* Rev 5

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21. WSRC-SA-17, *Consolidated Incineration Facility Safety Analysis Report,* (DOE Approval Copy 12/95)

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LEARNING OBJECTIVES

TERMINAL OBJECTIVE

1.0 Without references, **EXPLAIN** the significance of the Standby Diesel Generator to Consolidated Incinerator Facility operations, including its importance to safety, and the impact on operations of a failure of the system.

ENABLING LEARNING OBJECTIVES

1.1 **STATE** the purpose of the Standby Diesel Generator System.

1.2 Briefly **DESCRIBE** how the Standby Diesel Generator System accomplishes its intended purpose.

1.3 **EXPLAIN** the consequences of a failure of the Standby Diesel Generator System to fulfill its intended purpose, including the effects on other systems or components, overall plant operation, and safety.

TERMINAL OBJECTIVE

2.0 Using system diagrams, **EVALUATE** potential problems which could interfere with normal Standby Diesel Generator System flowpaths to determine their significance on overall system operation and the corrective actions needed to return the system to normal.

ENABLING LEARNING OBJECTIVES

2.1 **DESCRIBE** the physical layout of the Standby Diesel Generator System components including, the general location, how many there are, and functional relationship for each of the following major components:

a. Diesel Engine
b. Fuel Oil Daytank and Pump
c. Onan Generator
d. Automatic Transfer Switch
e. Test Load Bank
f. Transfer Switch
g. Local Alarm/Control Panel

2.2 **DESCRIBE** the Standby Diesel Generator System arrangement to include a drawing showing the following system components and interfaces with other systems:

a. Diesel Engine
b. Diesel Engine Fuel Oil system
c. Onan Generator
d. Automatic Transfer Switch
e. Test Load Bank
f. Transfer Switch

2.3 Given a description of the Standby Diesel Generator System equipment status, **IDENTIFY** conditions which interfere with normal system flowpaths.

2.4 Given a description of abnormal equipment status for the Standby Diesel Generator System, **EXPLAIN** the significance of the condition on system operation.

2.5 Given a description of the Standby Diesel Generator System equipment status, **STATE** any corrective actions required to return system operation to a normal condition.

TERMINAL OBJECTIVE

3.0 Given values of Standby Diesel Generator System operation parameters, **EVALUATE** potential problems that could effect the normal functioning of the system or its components to determine the significance of the existing condition and the actions required to return the system to normal operational.

ENABLING LEARNING OBJECTIVES

3.1 **DESCRIBE** the following major components of the Standby Diesel Generator System including their functions, principles of operation, and basic construction:

a. Diesel Engine
b. Electronic Fuel Control
c. Diesel Engine Starting Battery and Battery Charger
d. Local Alarm/Control Panel Annunciator Battery and Battery Charger
e. Lube Oil Level Indicator/Switch
f. Oil Level Regulator
g. Fuel/Water Separator
h. Fuel Oil Daytank and Transfer Pump
i. Onan Generator
j. Automatic Transfer Switch
k. Test Load Bank
l. Local Alarm/Control Panel

3.2 **STATE** the design capacities and operational limitations for the following Standby Diesel Generator System major components:

a. Diesel Engine
b. Diesel Engine Starting Battery and Battery Charger
c. Local Alarm/Control Panel Annunciator Battery and Battery Charger
d. Fuel Oil Daytank and Transfer Pump
e. Onan Generator
f. Test Load Bank and Transfer Switch

3.3 Given values for key performance indicators, **DETERMINE** if Standby Diesel Generator System components are functioning as expected.

3.4 **DESCRIBE** the following Standby Diesel Generator System instrumentation including, indicator location (local or Control Panel) sensing points and associated instrument controls.

a. Radiator Level-Indicating Switch
b. Fuel Oil Pressure
c. Lube Oil Level Indicator/Switch
d. Lubricating Oil Makeup Tank Level
e. Engine oil pressure
f. Water temperature gauge
g. Oil temperature gauge
h. Tachometer
i. Run time meter
j. AC volt meter
k. Amp meter
l. Frequency meter
m. Watt meter

3.5 **INTERPRET** the following standby diesel generator indicating lights:

a. D/G In Automatic Start Mode
b. Voltage Regulator No. 1 On
c. Voltage Regulator No. 2 On
d. ATS Failed To Transfer
e. Load Bank In Operation
f. Transfer Switch Closed

3.6 **INTERPRET** the following Standby Diesel Generator System alarms, including the conditions causing alarm actuation and the basis for the alarms:

a. D/G Set Overspeed
b. Engine Overcrank
c. Low-Low Engine Oil Pressure
d. High-High Engine Coolant Temperature
e. Emergency Stop Initiated at D/G
f. Loss of D/G Control Panel DC Control Circuit
g. Low Engine Oil Pressure
h. High Engine Coolant Temperature
i. High Engine Oil Temperature
j. Voltage Regulator Failure
k. D/G Auto Mode Disable
l. Engine Crankcase Low Oil Level
m. Starting Battery Low Voltage
n. Low Engine Coolant Level
o. Engine Jacket Water Temperature Low
p. Primary Fuel Filter Water Level High

q. Daytank Fuel Level Low
r. Power On
s. Engine Crankcase High Oil Level
t. Main Tank Fuel Oil Level

3.7 **EXPLAIN** how the following Standby Diesel Generator System equipment is controlled in all operating modes or conditions to include: control locations (local or Control Panel), basic operating principles of control devices, and the effects of each control on the component operation.

a. Standby Diesel
b. Generator
c. Load Bank
d. Fuel Oil System

3.8 **DESCRIBE** the interlocks associated with the following Standby Diesel Generator System equipment to include the interlock actuating conditions, effects of interlock actuation, and the reason the interlock is necessary.

a. Normal MCC 7 (8) Supply Low UV
b. D/G Output Voltage adequate
c. D/G Output frequency adequate
d. Test Load Bank Air Flow Failure
e. Oil/Block heaters On (Engine Oil Press and Temperature)
f. Oil/Block heaters Off (Engine Oil Press and Temperature)
g. D/G Overcrank Time
h. D/G Overspeed Shutdown
i. Low-Low Engine Oil Pressure Shutdown
j. High-High Coolant Temperature Shutdown
k. Emergency stop station

TERMINAL OBJECTIVE

4.0 Given necessary procedures or other technical documents and system conditions, **DETERMINE** the operator actions required for normal and off normal operation of the Standby Diesel Generator System including problem recognition and resolution

ENABLING LEARNING OBJECTIVES

4.1 **STATE** the personnel safety concerns associated with the Standby Diesel Generator System.

4.2 Given applicable procedures and plant conditions, **DETERMINE** the actions necessary to perform the following Standby Diesel Generator System operations:

a. Startup
b. Manual Operation of Equipment
c. Shutdown

4.3 **DETERMINE** the effects on the Standby Diesel Generator System and the integrated plant response when given any of the following:

a. Indications/alarms
b. Malfunctions/failure of components
c. Operator Actions

SYSTEM OVERVIEW

ELO 4.1	**STATE t**he personnel safety concerns associated with the Standby Diesel Generator System.

Safety

The following is a list of the possible hazards associated with the standby diesel generators:

- The batteries are a source of 24Vdc across the terminals when isolated.
- Fuel oil and fumes are flammable.
- Asphyxiation can be caused due to inadequate ventilation in the D/G enclosure.
- If the starting battery charger is left on "EQUALIZE" for more than 24 hours, potential for an explosion exists.
- Burns are possible from hot equipment when generator set is running.
- Oil should not be checked with dipstick while the engine is running.
- Enclosure louvers are motor operated.
- Outer louvers of the Test Load Bank become hot during operation.
- Coolant liquids can cause skin irritation.
- Engine could start automatically, if in the automatic mode, without warning.
- Safety glasses and gloves must be worn whenever operating engines.
- Acid goggles and gloves must be worn when handling fuel.
- Ear protection must be worn while the diesel is running.
- No smoking within 20 feet of a diesel engine, fuel tank, or inside a diesel enclosure.
- Rotating equipment is present; keep hands and loose clothing clear.
- Stand clear of battery bank during diesel starting cycle.
- Ensure power to oil/block heaters are turned off before draining the oil or coolant.
- Do not operate the battery disconnect switch unless the battery charger has been turned off.

Introduction

It is necessary to have some form of backup power in the event of a total loss of normal power to the area from the 13.8kV overhead lines. The incinerator kiln is draft-induced to support combustion. If there were no UPS or D/G sets and the area experienced a loss of normal power, kiln rotation would stop which would create a hot spot in the kiln where the mass of hot material rests. The induced draft (ID) fans would stop, which would lead to the possibility of a buildup of volatile fumes. We would have a potential hot spot in the kiln in combination with the possibility of volatile fumes as well as high temperature in the Quench Vessel due to the loss of all ID fans. (See Figure 1, *Diesel Generator Set Locations*)

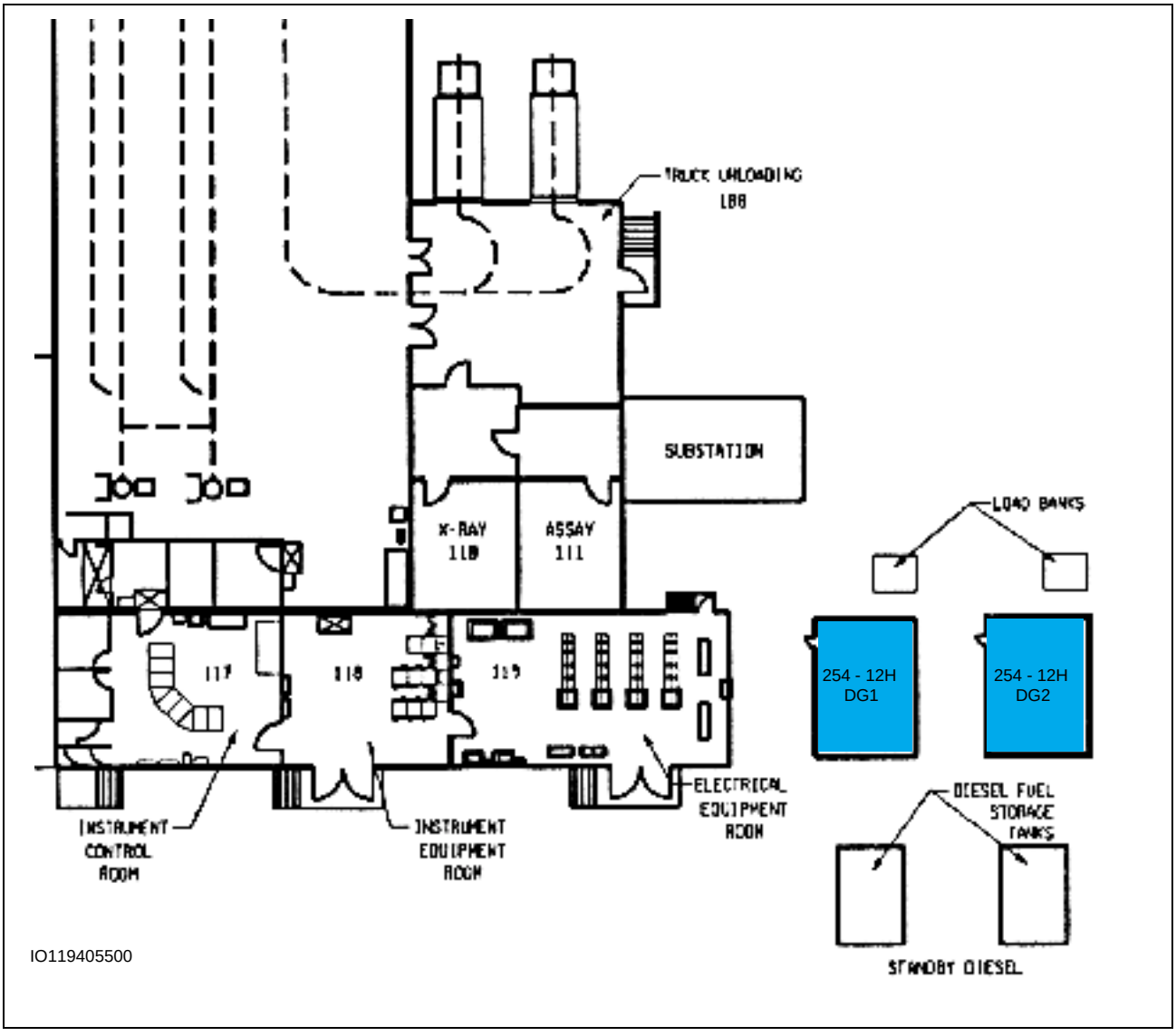

Figure 1 Diesel Generator Set Locations

Summary

- The diesels present a multitude of safety concerns to address when operating or testing. Heat, noise and fumes are a few of major concern.

- The Diesel Generator System consists of two (2) separate D/G sets with each capable of supplying power to its designated motor control center. Each set consists of an ATS, an external Test Load Bank, a Local Alarm/Control Panel, and other support equipment for the purpose of regulating fuel, voltage and power associated with the system.

SYSTEM PURPOSE

ELO 1.1	**STATE** the purpose of the Standby Diesel Generator System.
ELO 1.2	Briefly **DESCRIBE** how the Standby Diesel Generator System accomplishes its intended purpose.

Standby Diesel Generators System Purpose

The Standby Diesel Generator System (Standby Electrical Power) is provided as a standby source of power (480 Volts, 350 kW) for motor control centers (MCC) 7 and 8 in the event normal site power is interrupted to these MCCs. These two MCCs supply power to equipment considered essential for the safe and orderly shutdown of the incinerator.

The Standby Diesel Generator sets are designed and controlled to start automatically on loss of normal site power to their respective MCC (7 or 8). The voltage regulation and frequency (speed) are automatically controlled by the equipment. Once rated voltage and frequency are reached, the ATS will transfer the output of the D/G to its MCC.

Summary

- The Diesel Generator System is provided as a standby source of power (480V, 350 kW) for MCC 7 and 8 in the event normal site power is interrupted to these MCCs.

DESCRIPTION AND FLOWPATH

ELO 1.03 DRAW a one-line diagram showing the electrical flowpath from the standby diesel generator to the normal 480Vac system.

Description

The Diesel Generator System extends from the Fuel Oil Daytank to the ATS consisting of mechanical and electrical components required to drive two (2) 480V, 350kW generators. Each D/G set is a self-contained unit with a diesel engine driving a generator. Each D/G set contains: Support equipment, a Local Alarm/Control Panel for indication and local control; a Test Load Bank for surveillance testing; and an ATS. Each ATS (located in the electrical equipment room) is normally aligned to supply power from the 480V unit substation to its respective MCC (7 or 8). When the ATS senses a loss of normal voltage for greater than one (1) second, it closes a contact in the D/G starting circuit. The D/G starter motor (24Vdc, supplied by two (2) skid-mounted starting batteries) engages and turns the flywheel to start the engine. Once the D/G set is at rated speed and voltage, the ATS connects the output of the D/G to its respective MCC. (see Figure 2, *DG One Line*

The Standby D/G set is positioned in its own enclosure (see Figure 3, *Standby Diesel Generator Setup* and Figure 4, *D/G Set Enclosure*) located southeast of the electrical equipment room (EER), which houses most of the components required for operation. The 480V feeders connect the D/G output through underground conduits to the ATS in the EER. Normal configuration for the D/G set is in Standby (not-running) with the control switch on the Local Alarm/Control Panel in the AUTO START position. The engine coolant heater and oil heater are energized to maintain engine fluid temperature between 100°F to 120°F. This allows fast starts to rated speed with voltage and loading, without a warm-up period of running at idle with no load. The D/G starting battery charger is normally on and maintaining a float charge on the starting batteries. The fuel tank is located directly behind the enclosure.

Each D/G enclosure is provided with a lighting panel, 120Vac power to the D/G control panel, fuel oil supply line heat tracing, interior lighting and electric heater/blower. Also supplied is an enclosure exhaust fan and two (2) motorized louvers in the enclosure walls. These louvers open on a D/G start signal to provide an adequate supply of air for the D/G Inlet Air System, which takes suction inside the enclosure. On the outside west wall of each enclosure, adjacent to the west access door, is the D/G emergency stop pushbutton. This device is actuated by breaking the glass cover over the pushbutton.

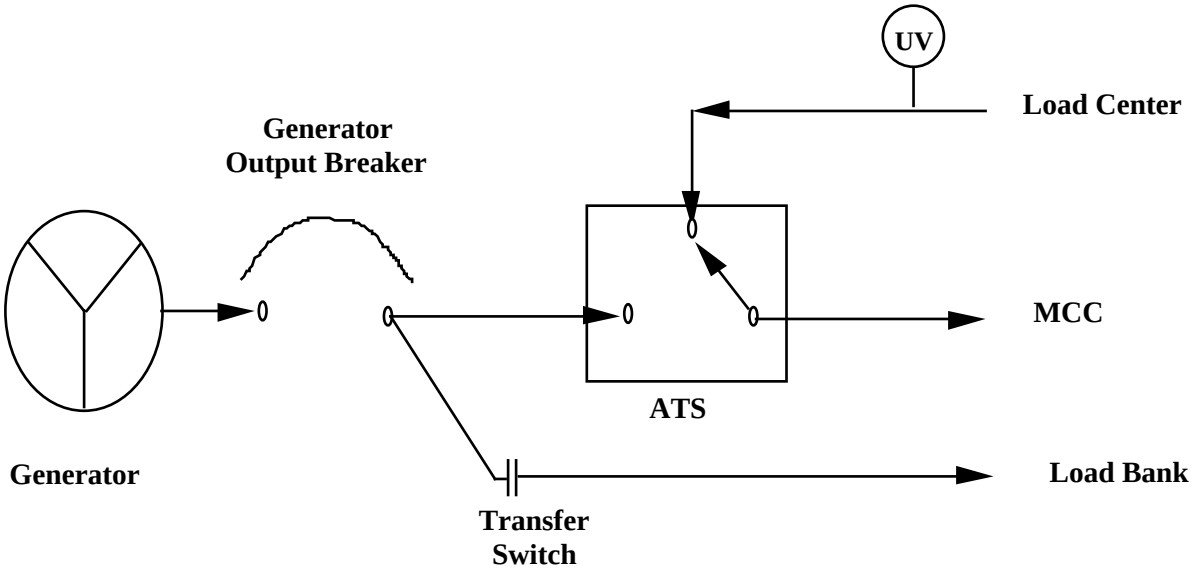

Figure 2 D/G One Line

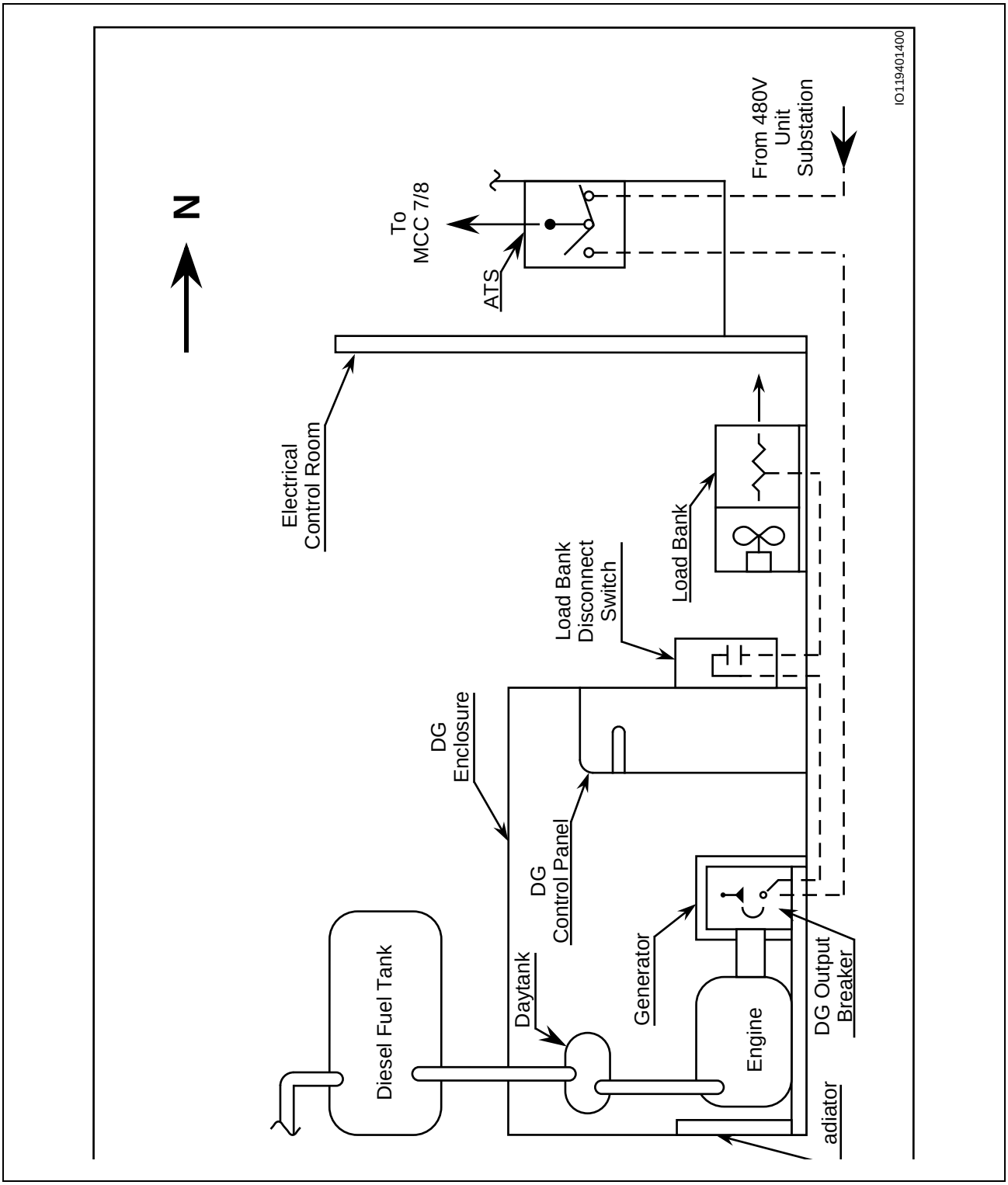

Figure 3 Standby Diesel Generator Setup

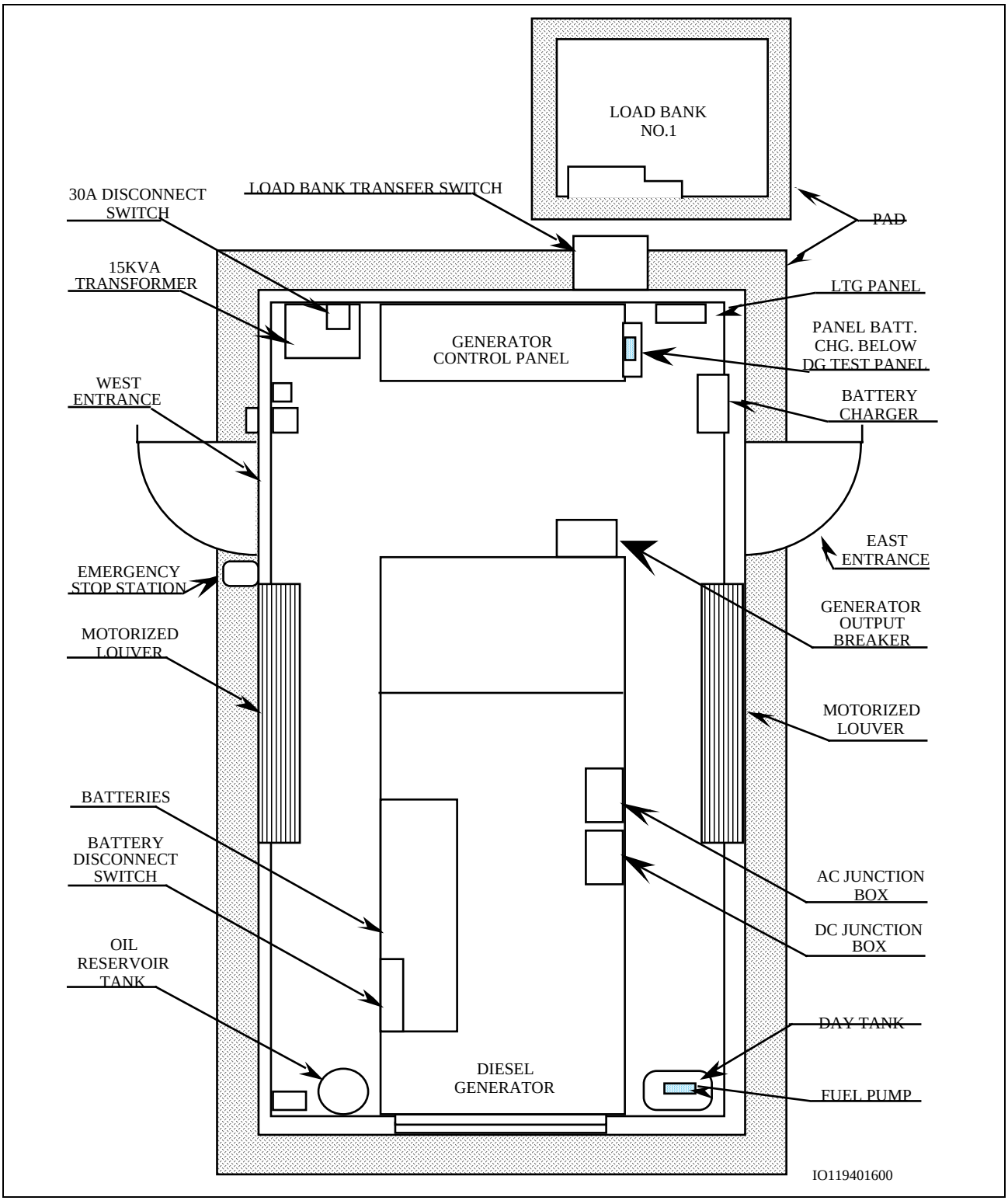

Figure 4 D/G Set Enclosure

Summary

- When the ATS senses a loss of normal voltage for greater that one second, it closes a contact to start the D/G set. Once the D/G set is at rated speed and voltage, the ATS connects the output of the D/G to its respective MCC.

- The Diesel Generator System consists of mechanical and electrical components required to drive two 480V, 350kW generators and supply standby power to essential 480V MCCs 7 and 8 for the safe and orderly shutdown of the incinerator on loss of normal power.

MAJOR COMPONENTS

ELO 1.04	**DESCRIBE characteristics of each major component associated with the Standby Diesel Generator System, to include:** **a. Diesel Engine** **b. Onan Generator** **c. Fuel Oil Daytank** **d. Automatic Transfer Switch (ATS)**
ELO 1.06	**DESCRIBE the function of the following major components within the Standby Diesel Generator System:** **a. Diesel Engines** **b. Onan Generator** **c. Fuel Oil Daytank** **d. Automatic Transfer Switch (ATS)** **e. Test Load Bank**
ELO 1.07	**Identify the key performance indicators used to verify correct operation of the following Standby Diesel Generator System components:** **a. Diesel Engine** **b. Onan Generator** **c. Fuel Oil Daytank** **d. Automatic Transfer Switch (ATS)** **e. Test Load Bank**

Diesel Engine

The diesel engines are in-line, six cylinder, turbo-charged, Cummins Atlantic, 4-cycle engines. The engines are forced oil-lubricated (48 quart capacity) and each uses a fan/radiator in conjunction with a belt driven water pump for cooling. The cooling fluid capacity is 24 gallons.

While in operation, a thermostatic valve regulates coolant flow to the radiator to maintain the coolant temperature between 160 and 200˚ F. Indications available on the engine are coolant (radiator) level, oil level, and fuel oil pump discharge pressure. A level indicator is provided on the Fuel Oil Daytank located next to the engine.

The diesel engine is provided with a forced-air radiator cooling system, oil and cooling water heaters, batteries and a battery charger, an intake air filter, and an exhaust muffler.

Electronic Fuel Control Governor

The Speed of the D/G is controlled by the Cummins Electronic Fuel Control Governor which contains a magnetic pickup, a governor control, an actuator and the mounting parts. The governor uses the input of the magnetic pickup mounted at the engine flywheel. The magnetic pickup senses engine speed at the flywheel ring gear and sends an AC signal to the governor control. The governor control compares the electrical signal from the magnetic pickup with a preset reference point. If there is a difference in the two signals, the control will change the current to the EFC Actuator, an electromagnetic rotary solenoid valve. The actuator shaft will turn controlling the output of the diesel engine fuel oil pump, thereby controlling the fuel flow to the injectors. The actuator is installed in the EFC cavity of the PT fuel pump. The fuel flows through the actuator to the shutoff valve.

The shutoff valve is a solenoid valve located in the fuel oil outlet of the actuator. The D/G interlocks interrupt power to the solenoid valve closing it, which stops fuel oil to the injectors. The Engine Control Switch must be place in the Off-Reset position to reset the shutoff valve.

Starting Battery Charger

The charger for the starting batteries is constant voltage, manually switched, two rate (float and equalize), current limited. It is powered from the 208/120V lighting panel in the D/G enclosure. The charger senses battery terminal voltage and compares it to a factory set reference voltage, adjusting current output as required (up to the current-limit setpoint of 10 amps) to maintain battery voltage. Normal current indication should be 1 to 2 amps. With the float-equalize switch in the EQUALIZE position, a resistor is added to the sensing circuit to reduce the terminal voltage seen by the regulator voltage-comparing circuit. This will increase the charger output voltage, to approximately 30 Volts. The current indicated will increase initially then decrease as the battery voltage increases to the output voltage of the charger. The equalize circuit is used to equalize the voltage of all the battery cells.

Starting Battery

Two batteries are provided for starting the D/G set. They are 12V batteries rated at 1150 amperes cranking performance with a 405-minute reserve capacity. These batteries are connected in series to provide 24Vdc output for the starting motor.

Local Alarm/Control Panel Battery Charger

The Local Alarm/Control Panel Battery Charger is provided to maintain the annunciator battery charged, it is powered from the D/G 208/120V lighting panel with a 24Vdc output. It is a constant voltage, single-rate (float), regulated charger.

Local Alarm/Control Panel Battery

Two batteries are provided to supply the annunciator power supply on the Local Alarm/Control Panel. They are 12V sealed batteries connected in series to provide 24Vdc output for the Local Alarm/Control Panel.

Lube Oil Level Indicator/Switch

The engine is provided with a float actuated level indicator/switch. The indicator/switch is mounted on the battery side of the D/G on the engine crankcase at the oil pan level. Switch contacts (High and Low) are activated by a float which serves as the level indicator. The high- or low-level condition causes a corresponding alarm on the Alarm/Control Panel in the D/G enclosure.

Oil Level Regulator

The engine is provided with an automatic lube oil makeup. A five (5) gallon reservoir is located above, and connected by tubing to a float/valve unit connected to the engine crankcase at normal oil level. The oil level regulator is mounted on the Daytank side of the engine. The float will keep the makeup valve closed unless oil level decreases below normal. At that point the valve opens and oil is gravity fed to the crankcase. Increasing oil level will raise the float and close the valve. The makeup reservoir is provided with a level sight gauge, measured in gallons, a filter cap and an isolation valve.

Fuel/Water Separator

Dual in-line parallel fuel filters are provided in the suction to the engine-driven fuel oil pump. The first set are three-stage filters which act to remove water and sediment from the fuel oil. The first stage uses flow direction change and centrifugal action to remove the heavier liquid and solid contamination. The second stage collects the liquid contamination that remained in suspension in the fuel. As the contaminates collect on the interior of the unit, the beads become heavier until they drain to the bottom of the bowl. A water sensor is provided in each filter bowl. These are conductivity probes with a lower voltage signal present when activated. A rising water level will complete the circuit when it reaches probe level. This will cause an alarm (Primary Fuel Filter Water Level High) on the Local Alarm/Control Panel to alert the operator that the filter needs to be drained.

The third (final) stage is a set of two replaceable cartridge filters mounted in parallel where the last of the small particulates are removed. The engine must be off or the filter isolated before draining since the cover must be open to relieve the vacuum created by the suction of the engine driven fuel oil pump.

ELO 1.05 Given the fuel oil consumption rate of a standby diesel, calculate the runtime of the diesel based on the volume of fuel oil available.

Diesel Fuel Oil Daytank

The Diesel Fuel Oil Daytank has a 10-gallon capacity and provides suction to the engine driven fuel oil pump. The full load fuel consumption rate is approximately $\frac{1}{2}$ gpm. The daytank is provided with a positive displacement supply pump (2 gpm nominal, $\frac{1}{3}$ HP single-phase motor), powered from the local power panel, which is controlled by level switches to keep the daytank full. The daytank supply pump takes suction from its respective Diesel Fuel Storage Tank (located south of the D/G enclosures in catch basins), sized at 660 gallons (615 usable) to provide greater than 16 hours of continuous full load operation. The suction line is provided with a foot valve in the Diesel Fuel Storage Tank to maintain pump prime, and is heat traced and insulated to reduce condensation in the fuel supply. The supply pump is powered from the local lighting panel. A control panel on the Daytank includes a Push To Test, a Pump Running light and a Fuel Low light. A float gauge indicates tank level and is located on the top of the Daytank. The gauge is calibrated in one eighth gallon increments. When the Push To Test switch is depressed the pump will start, the solenoid will open and the Pump Running light will illuminate. The Push To Test switch does not have lock in control.

Onan Generator

Two Onan Generators, 480V, 3-phase, 60 Hz electric generators, are driven by their respective diesel engines, air-cooled, and provided with an (normally closed) 1000 amp output breaker. Each generator is provided with a 120V space heater to keep the windings dry when the generator is in standby mode. The generator output voltage and amperage indications are provided on the Local Alarm/Control Panel. Both the voltage and amperage indicators have a selector switch to allow reading each of the three phases. Generator output frequency is also displayed on the panel which can be used for speed indication by converting the frequency to rpm at 30 rpm for a 1 Hz ratio.

Automatic Transfer Switch (ATS)

The automatic transfer switches are located in the Electrical Control Room (ECR). They are connected to the 480V unit substation or the D/G sets by cables in underground conduit. The ATS maintains the 480V feed to MCC(s) (7 and 8) transferring automatically to the available power supply.

DCS status is provided for ATS position. When aligned to the 480V unit substation, "NORMAL" is displayed. When aligned to the D/G set, "EMERGENCY" is displayed.

The switch monitors its normal feeder, and once power is restored, will automatically switch to the 480V unit substation after a 30-minute time delay (to ensure stability of the supply). The ATS is also provided with local controls and indications on the front panel of its control cabinet.

Indicating Lights

- A green Load Connected To Normal light
- A red Load Connected To Emergency light

Switches

- Key-operated transfer test switch, spring return. This switch must be held in the Test position for 15 seconds to initiate the following function: simulate a loss of normal supply, initiating a D/G automatic start and transfer load to the Standby Diesel Generator. When the key is released the switch will return to normal position.
- Key operated selector switch, (two positions):

  AUTO TRANSFER - In this position, all ATS functions are completed automatically.

  MANUAL TRANSFER - In this position, transfer to the normal supply will not take place after the normal 30-minute time delay.
- Toggle switch, spring return. RESET TO NORMAL position will initiate an ATS transfer from the Standby Diesel Generator to normal supply with the selector switch in the MANUAL RETRANSFER position.

Test Load Bank

The load banks are outdoor units supplied to provide a load of up to 400kW (resistive) for periodic local/manual exercise/testing of the D/G set. This will verify operability of the D/Gs while in the (normal) automatic/standby mode.

The two (2) load banks are housed in outdoor enclosures that contain load element resistor assemblies with eight (8) resistor groups. Each group of resistors is rated at 50kW load. Two groups can be switched on individually for a 50kW load step change. The remaining six (6) groups can be switched on in pairs for a total of three (3) 100 kW load step changes. These resistor groups will be controlled from the Test Load Bank Control Panel (located in the D/G enclosure on the east end of the D/G Local Alarm/Control Panel).

Each load bank is provided with a heater and a fan for temperature control of the assembly. If the cooling fan fails (Air Failure light on at the Test Load Bank Control Panel), the failure electrically interlocks (transfer switch open) the control circuit to prevent load application.

The Test Load Bank Control Panel (see Figure 5, *Test Load Bank Control Panel*) is located in the D/G enclosure on the east end of the Local Alarm/Control Panel. The panel has a power ON-OFF switch with a control power light, blower Start and Stop pushbuttons with Blower Power and Air Failure lights, and individual load step switches (two-50kW and three-100kW). A Master Load switch on the panel must also be operated to supply power to the individual load bank relays. Except for the blower pushbuttons, all switches are toggle type with metal levers.

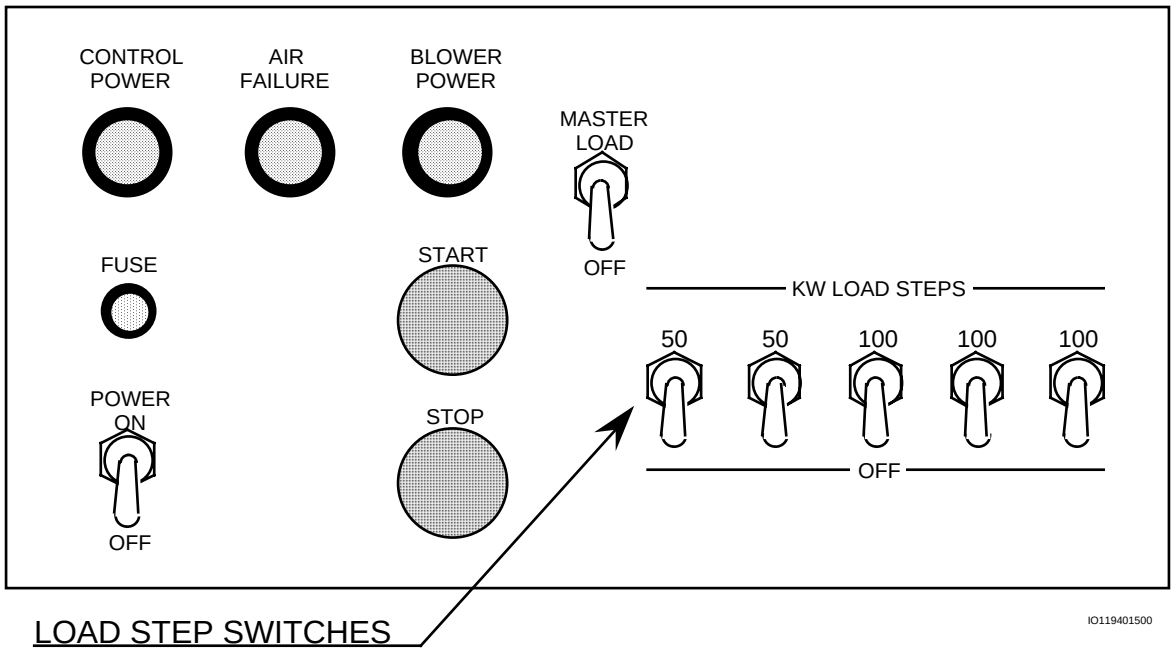

Figure 5 Test Load Bank Control Panel

The load bank transfer switch is provided to tie the load bank to the output of the D/G output breaker. It is controlled by, Transfer Switch Open Pushbutton (TSOPB) and the Transfer Switch Close Pushbutton (TSCPB), on the Local Alarm/Control Panel. A Transfer Switch Closed light will illuminate when the TSCPB is pushed. If the transfer switch fails to close an ATS Failed To Transfer light will illuminate. Since load bank control power and power for the cooling fan are taken from the 480V feed to the load bank, this switch must be closed to place the load bank in service. Before closing the transfer switch, all switches at the Load Bank Control Panel should be verified OFF, and the D/G set must be at rated speed and voltage. If the load bank control panel Power On Switch and the Master Load Switch were left on and a load bank switch where left in the Load/Up position, closing of the transfer switch could draw an arc doing damage to the switch.

A Load Bank In-Operation light will illuminate when any one of the KW Load Step switches is placed in the Load/Up position.

Local Alarm/Control Panel

The Local Alarm/Control Panel is provided for operation and surveillance of the D/G set. Each enclosure houses a panel for each set with each being identical. The panel can be seen in Figure 6, *Local Alarm/Control Panel* (see Tables 1, 2 & 3 for explanation of indicating lights). Most of the instrumentation associated with the D/G set is located on the Local Alarm/Control Panel. The Local Alarm/Control Panel has sufficient instrumentation, alarms, and controls to run the D/G set locally and monitor system conditions during automatic operation. The annunciators that light RED are the items that will initiated a D/G Trouble alarm on DCS.

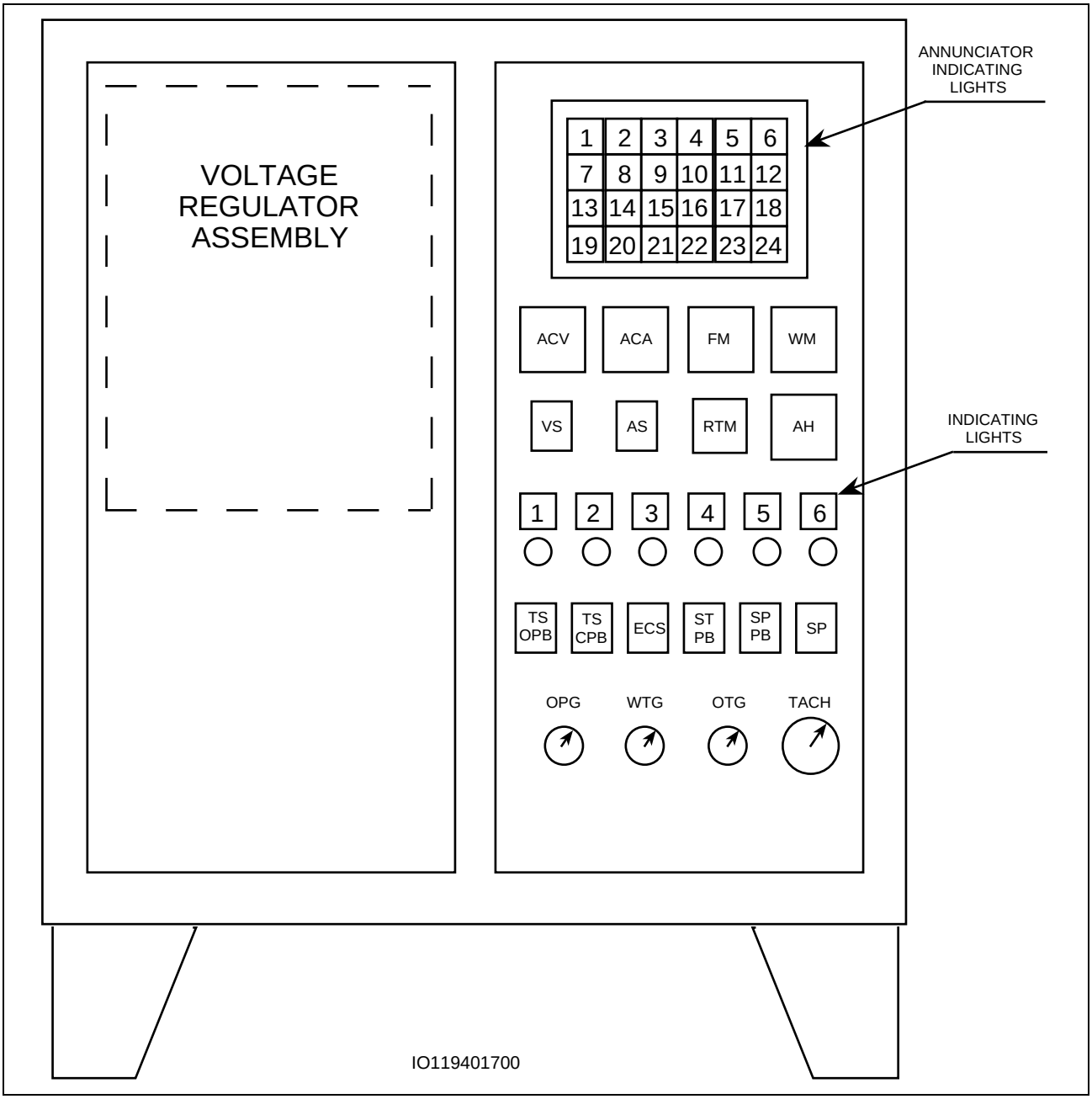

Figure 6 Local Alarm/Control Panel

Number	Description	Color
1	D/G Set Overspeed	RED
2	Engine Overcrank	RED
3	Low-Low Engine Oil Pressure	RED
4	High-High Engine Coolant Temperature	RED
5	Emergency Stop Initiated At D/G	RED
6	Loss of D/G Control Panel DC Control Circuit	RED
7	Low Engine Oil Pressure	AMBER
8	High Engine Coolant Temperature	AMBER
9	High Engine Oil Temperature	AMBER
10	Voltage Regulator Failure	AMBER
11	D/G Auto Mode Disable	AMBER
12	Engine Crankcase Low Oil Level	AMBER
13	Starting Battery Low Voltage	AMBER
14	Low Engine Coolant Level	AMBER
15	Engine Jacket Water Low Temperature	AMBER
16	Primary Fuel Filter Water Level High	AMBER
17	Daytank Fuel Level Low	AMBER
18	Power On	White
19	Engine Crankcase High Oil Level	AMBER
20	Main Tank Fuel Oil Level	AMBER
21	Spare (No Engraving)	N/A
22	Spare (No Engraving)	N/A
23	Spare (No Engraving)	N/A
24	Acknowledge And Test Buttons	N/A

Table 1 Annunciator Indicating Lights

Number	Description	Color
1	D/G In Auto Start Mode	GREEN
2	Voltage Regulator No.1 On	GREEN
3	Voltage Regulator No.2 On	AMBER
4	ATS Failed To Transfer	RED
5	Load Bank In Operation	WHITE
6	Transfer Switch Closed	WHITE

Table 2 Indicating Lights

Abbreviations	Description
ACA	AC Ammeter
ACV	AC Voltmeter
AH	Alarm Horn
AS	Ammeter Switch
ECS	Engine Control Switch
FM	Frequency Meter
OPG	Oil Pressure Gauge
OTG	Oil Temperature Gauge
RTM	Run Time Meter
SP	Speed Potentiometer
SPPB	Stop Pushbutton
STPB	Start Pushbutton
TACH	Tachometer
TSCPB	Transfer Switch Close Pushbutton
TSOPB	Transfer Switch Open Pushbutton
VS	Voltmeter Switch
WM	Wattmeter
WTG	Water Temperature Gauge

Table 3 Figure 6 Abbreviations

Summary

- The diesel engines are in-line, six cylinder, turbo-charged, Cummins Atlantic diesel engines. The engines are forced oil-lubricated, and each uses a fan/radiator in conjunction with a belt- driven water pump for cooling. Full load fuel consumption rate is approximately $\frac{1}{2}$ gpm.

- Two Onan Generators, 480V, 3-phase, 60 Hz, are driven by their respective diesel engines. The generator output voltage and amperage indications are provided on the Local Alarm/ Control Panel.

- The Diesel Fuel Oil Daytank provides gravity suction to the engine fuel oil pump. The daytank has a 10-gallon capacity.

- The ATS is provided to switch from normal feed (480V unit substation) to the standby D/G 480V supply for MCCs 7 or 8 on a loss of the normal power supply. They are located in the ECR.

- The load banks are outdoor units designed to absorb a balanced resistive load of unity power factor. Each D/G Test Load Bank is rated for a load of 400kW at 480V, 3-phase, 60 Hz. The Test Load Bank Control Panel is located in the D/G enclosure on the east end of the Local Alarm/Control Panel.

- The Local Alarm/Control Panel is provided for operation and surveillance of the D/G set. Each enclosure houses a panel for each set, with each being identical.

INSTRUMENTATION

ELO 1.08 **DESCRIBE the function of the following Diesel Generator instrumentation associated with the Standby Diesel Generator System:**

a. AC volt meter

b. Amp meter

c. Frequency meter

d. Watt meter

Generator Instrumentation

The majority of the instrumentation associated with the D/G sets is contained on the Local Alarm/Control Panel. The Local Alarm/Control Panels are located in the D/G enclosure (See Figure 1 and/or 3). The panel is identical in function and layout for both D/G sets. For a general layout of the Local Alarm/Control Panel, see Figure 6 and Tables 1, 2 and 3.

AC Volt Meter

The AC volt meter indicates the generator AC output voltage with a range of 0 to 600Vac. A selector switch is provided to read volts from phase to phase (A-C, A-B, B-C). The input is from the 480-120V potential transformer, which monitors the D/G output voltage.

AC Amp Meter

The amp meter (ammeter) indicates the generator output amperage with a range of 0 to 600 amps. A selector switch is provided to read amperage from each phase (A, B, C). Input is from a 600 to 5 ratio current transformer, located on each phase of the generator output.

Frequency Meter

The frequency meter indicates the frequency of the generator AC output voltage with a range of 55 to 65 Hz. The input is from the 480-120V potential transformer which monitors the D/G output voltage.

Watt Meter

The watt meter indicates the generator output in Kilowatts with a range of 0 to 500kW. The input is from the 480-120V potential transformer and the 600 to 5 ratio current transformer.

ELO 1.09 **DESCRIBE the function of the following local diesel engine indications associated with the Standby Diesel Generator System:**

a. Radiator level indicating switch
b. Fuel oil pressure
c. Lubricating oil level indicating switch
d. Lubricating oil makeup tank level
e. Engine oil pressure
f. Water temperature gauge
g. Oil temperature gauge
h. Tachometer
i. Run time meter

Diesel Engine Instrumentation

Radiator Level-Indicating Switch

The radiator level-indicating switch is float-actuated and sets even with the top of the radiator core. This item indicates normal to low coolant levels. The switch has a test knob which can be turned to cause the indicating needle to pick up the low-level switch.

Fuel Oil Pressure

The fuel oil pressure monitored by a pressure gauge located at the engine driven fuel oil pump discharge. The gauge has a range of 0 to 200 psig and is used for indication only.

Lubricating Oil Level-Indicating Switch

The lubricating oil level-indicating switch is float-actuated and indicates the actual crankcase oil level. The float contacts high or low setpoints (adjustable) for alarm purposes. The high and low setpoints are approximately 2 inches above and below the normal oil level, respectively.

Lubricating Oil Makeup Tank Level

The lubricating oil, makeup tank level is a sight gauge located on the oil makeup tank and is used for indication only.

Engine Oil Pressure Gauge

The engine oil pressure gauge indicates lubricating oil pressure with a range of 0 to 100 psi. The input is from an engine-mounted sensor in the oil piping.

Water Temperature Gauge

The water temperature gauge indicates engine coolant temperature with a range of 100°F to 230°F. The input is from an engine-mounted sensor in the coolant piping.

Oil Temperature Gauge

The oil temperature gauge indicates lubricating oil temperature with a range of 140°F to 320°F. The input is from an engine-mounted sensor in the oil piping.

Tachometer

The tachometer indicates engine speed with a range of 0 to 2500 rpm. The input is from the Cummins Electronic Fuel Controller, which uses the input of the magnetic pickup mounted at the engine flywheel.

Run Time Meter

The run time meter indicates cumulative run time of the D/G set with a range of 0.0 to 99999.9 hours. The input is voltage sensed from the Potential Transformer Secondary (480 to 120V transformer) which monitors the D/G output voltage. This meter is provided for planning periodic maintenance based on total hours of operation.

ELO 1.10 **Describe the function of the following standby diesel generator indicating lights:**

a. D/G In Auto Start Mode
b. Voltage Regulator No. 1 On
c. Voltage Regulator No. 2 On
d. ATS Failed To Transfer
e. Load Bank In Operation
f. Transfer Switch Closed

Alarm/Control Panel Indication Lights

Each of the six (6) indicating lights is the "push to test" type (see Figure 6, *Local Alarm/Control Panel*, and Table 2). Pushing in the lens cap of each light will cause the light to illuminate if not already lit. This allows for testing of the lamps. The indications are as follows:

D/G In Auto Start Mode (green)

The "D/G In Auto Start Mode" light is illuminated when both the D/G output breaker is closed and the Engine Control Switch (ECS) is in the AUTO START position.

Voltage Regulator No. 1 on (green)

With the engine running, the No. 1 voltage regulator conduction-sensing relay closes a contact to illuminate this light.

Voltage Regulator No. 2 on (amber)

With the engine running, the No. 2 voltage regulator conduction-sensing relay closes a contact to illuminate this light.

ATS Failed To Transfer (red)

The ATS Failed To Transfer indication alerts the operator that the Test Load Bank contactor did not close (contact for circuit failed to connect the diesel generator to the load bank) when the TSCPB was depressed.

Load Bank In Operation (white)

The Load Bank In Operation indication illuminates when any of the individual load step switches are closed on the Local Alarm/Control Panel.

Transfer Switch Closed (white)

The Transfer Switch Closed indication confirms to the operator that the load bank transfer switch is closed tying the load bank to the output of the Generator when the TSCPB was depressed. The only contact between the Generator and the load bank are the kW Load Step toggle switches on the Load Bank Control Panel.

Summary

- The majority of the instrumentation associated with the D/G sets is contained on the Local Alarm/Control Panels located in the D/G enclosure.
- The following instrumentation is used to display information needed to monitor the operation of the Diesel Engine:
  - Engine oil pressure
  - Water temperature gauge
  - Oil temperature gauge
  - Run time meter
  - Tachometer
  - Radiator Level-Indicating Switch
  - Fuel Oil Pressure
  - Lubricating Oil Level-Indicating Switch
  - Lubricating Oil Makeup Tank Level
- The following instrumentation is used to display information needed to monitor the operation of the Onan Generator:
  - AC volt meter
  - Amp meter
  - Frequency meter
  - Watt meter
- Each of the six (6) Alarm/Control Panel Indication Lights is the "push to test" type. They not only indicate the operating mode of the D/G, but also show voltage regulator operation and transfer switch position.

CONTROLS, INTERLOCKS AND ALARMS

ELO 1.11 DESCRIBE the function of the following Standby Diesel Generator controls:

a. Transfer switch open pushbutton
b. Transfer switch close pushbutton
c. Engine control switch
d. Start pushbutton
e. Stop pushbutton
f. Speed potentiometer
g. Emergency stop pushbutton

Controls

The only operator-accessible controls for the D/G sets are located on the Local Alarm/Control Panel (See Figure 5 and Tables 1, 2 & 3) with the exception of the Emergency Stop Pushbutton which is located on the exterior of the D/G enclosure at the west access door.

Transfer Switch Open Pushbutton

When the transfer switch is closed, this pushbutton opens a normally-closed contact in series with the control relay to drop it out and cause the transfer switch to open de-energizing the load bank.

Transfer Switch Close Pushbutton

The transfer switch is normally open. The close pushbutton closes the transfer switch and an auxiliary contact (seal in) in parallel with the close pushbutton. When the close pushbutton is released, the seal in contact maintains 120Vac control power on the control relay coil energizing the load bank.

Engine Control Switch

This oval grip, four-position-maintained switch is a cam-operated, General Electric type SBM with LB contact blocks, five (5) of which are used. Positions/functions are as follows:

AUTO START - Closes three (3) contacts in the D/G starting circuit. One is in series with the normally-open remote start contact (located in the Auto Transfer Switch) which closes on loss of normal operation to start the D/G set protective relays (low-low oil pressure, high- high water temperature, over-speed, and overcrank), and to ensure the D/G will trip if required. The other contact is in series with the four (4) D/G set protection relays.

MANUAL START - Closes two (2) contacts in the D/G starting circuit. It is in series with the normally-closed stop pushbutton and normally-open start pushbutton. Pushing the start pushbutton (momentary contact) will then start the engine. A parallel seal in contact then closes, locking in the run relay. Pushing the stop pushbutton momentarily opens the control circuit, stopping the engine.

OFF/RESET - Either of the two positions labeled OFF/RESET opens all automatic and manual position contacts. No automatic (remote) or local (manual) start is possible. The Engine Control Switch must be placed in this position momentarily following any automatic shutdown to reset the Solenoid valve on the discharge of the EFC Valve.

Start Pushbutton

With the engine control switch in the MANUAL START position, pushing the start pushbutton will start the D/G set.

Stop Pushbutton

With the engine control switch in the MANUAL START position and the D/G set running, pushing the stop pushbutton will stop the D/G set.

Speed Potentiometer

Not normally adjusted. During initial startup or after calibration/maintenance on the electronic speed controller, this potentiometer can be used to fine tune engine speed to 1800 RPM (when less than +100 rpm correction is required). This potentiometer has no external handle and is provided with a lock nut to prevent inadvertent operation. The Speed Potentiometer provides the preset reference point used by the electronic speed controller (governor control) to compare the electrical signal from the magnetic pickup. The error signal is then sent to the EFC adjusting the fuel oil supply to the injectors for speed control.

Emergency Stop Pushbutton

One Emergency Stop Pushbutton is provided for each D/G set on the exterior of the D/G enclosure at the west access door. This is an ASCO break glass station with a glass face over the pushbutton. The pushbutton is held in against a spring by the glass face, which maintains the switch contacts open. Breaking the glass face of the station releases the pushbutton, closing its contacts. This actuates the emergency stop, initiating a D/G alarm on the alarm panel, and energizes the engine failure relay, stopping the engine. This pushbutton, once actuated, can only be reset by replacing the glass face in the cover. Once the cover is closed, the pushbutton is again held in, maintaining its contact open.

ELO 1.14 **EXPLAIN the operation of the CIF Standby Diesel Generator System interlocks, to include the interlock actuating conditions, effects, and reasons for the interlocks.**

Interlocks

The system setpoints for the standby diesel generator sets are tabulated in Tables 4, 5, & 6.

Interlock/Control	Setpoint
Normal MCC 7 (8) Supply Low (UV)	408Vac (dec.)
D/G Output Voltage adequate	432Vac (inc.)
D/G Output frequency adequate	57 Hz (inc.)
Test Load Bank Air Flow Failure	Fan power failure
Oil/Block heaters On	100˚ F (dec.)
Oil/Block heaters Off	120˚ F (inc.)
Oil/Block heaters Off (Engine Oil Press)	12 psig (inc.)
D/G Overcrank Time	75 sec.
D/G Overspeed Shutdown	2100 RPM ± 90
Low-Low Engine Oil Pressure Shutdown	12 psig (dec.)
High-High Coolant Temperature Shutdown	205˚ F (inc.)

Table 4 Interlocks and Controls

ELO 1.12 **INTERPRET the following alarms associated with the Diesel General System, including the conditions causing alarm actuation and the bases for the alarms:**

a. Low Engine Oil Pressure
b. High Engine Coolant Temperature
c. High Engine Oil Temperature
d. Engine Crankcase Low Oil Level
e. Starting Battery Low Voltage
f. Low Engine Coolant Level
g. Engine Jacket Water Temp Low
h. Primary Fuel Filter Water Level High
i. Engine Crankcase High Oil Level

Alarms

Alarms are indicated on the Panalarm Annunciator System. A lamp test pushbutton is provided to test the window bulbs. An acknowledge pushbutton is provided to acknowledge alarms. Any alarm received sounds the alarm horn, located on the face of the D/G Local Alarm/Control Panel. Each alarm window will flash when received and sound the horn. Pushing the acknowledge pushbutton will silence the horn and change the window light to steady on. A power on light is also provided (24Vdc supply from an integral battery power supply supplied from the D/G Local Alarm/Control Panel 24Vdc control circuit).

Any RED alarm received on the D/G Local Alarm/Control Panel will cause a DCS D/G TROUBLE alarm, which should be investigated immediately. The alarms are the first eight alarms listed in Table 5, *Alarms.*

Alarms	Setpoint
D/G Set Overspeed	2100 rpm ± 90
Engine Overcrank	75 seconds
Low-Low Engine Oil Pressure	12 psig (dec.)
High-High Engine Coolant Temperature	205˚ F (inc.)
Emergency Stop Initiated at D/G	N/A
Loss of D/G Control Panel DC Control Circuit	Blown Fuse Open Disconnect
Low Engine Oil Pressure	16 psig (dec.)
High Engine Coolant Temperature	200˚ F (inc.)
High Engine Oil Temperature	250˚ F (inc.)
Voltage Regulator Failure	Blown Fuse
D/G Auto Mode Disable	Sw. Not In Auto Position
Engine Crankcase Low Oil Level	2" Below Normal
Starting Battery Low Voltage	21 Volts
Low Engine Coolant Level	1" Below Top of Core
Engine Jacket Water Low Temperature	90˚ F
Primary Fuel Filter Water Level High	2" In Bowl
Daytank Fuel Level Low	Less Than 3/8 Full
Power On	Switch Position
Engine Crankcase High Oil Level	2" Above Normal
Main Tank Fuel Oil Level	515 Gallon

Table 5 Alarms

Parameters

Parameter	Operating Range
Oil Pressure	40-100 psig
Oil Temperature	180-225˚ F
Coolant Temperature	160-200˚ F
Engine Oil Heater	100-120˚ F
Generator Volts	470.4-489.6 Vac.
Generator Amps	≤ 530 A
Generator Frequency	58.8-61.2 Hz
Generator Power	≤ 365 kW
Engine Speed	≤1850 RPM
Engine Oil Level	> L - < H
Engine Coolant level	> MIN - < MAX
Battery Voltage (at charger)	23.95 - 24.05 volts
Lube Oil Makeup Tank Level	>1/2

Table 6 Parameters

Summary

- The only operator-accessible controls for the D/G are located on the Local Alarm/Control Panel with the exception of the Emergency Stop Pushbutton, which is located on the exterior of the D/G enclosure at the west access door.
- The transfer switch, open and close pushbuttons, operate the Load Bank Transfer Switch manually.
- The Engine Control Switch is a four-position-maintained switch.
- The Start and Stop pushbuttons are used to operate the D/G when in the Manual Mode.
- The Speed Potentiometer is used during initial startup or after calibration/maintenance on the electronic speed controller. This potentiometer can be used to fine tune engine speed to 1800 rpm.
- The Emergency Stop Pushbutton is provided to actuate the emergency stop, initiating a D/G alarm on the alarm panel, and energize the engine failure relay, stopping the engine.
- Any RED alarm received on the D/G Local Alarm/Control Panel will cause a DCS D/G TROUBLE alarm.

SYSTEM INTERRELATIONS

Plant Electrical System

The interface point between the Diesel Generator System and the Plant Electrical System is the automatic transfer switches located on the north wall of the ECR. The switches are normally connected to the 480V unit substation via underground cables in conduit. On a loss of this normal feed (and after diesel generator start), they connect the diesel generator output to their respective MCC (7 or 8). The D/G 480V output cables are routed to the ATS via underground conduit also.

Diesel Fuel Oil System

The interface point between the Diesel Generator System and the Diesel Fuel Oil System is the Diesel Fuel Oil Daytank located inside the diesel generator enclosure. A supply pump sets on top of the daytank to supply diesel fuel oil to the daytank from the main fuel tank.

DCS

The DCS interfaces with the diesel generator sets via the D/G Alarm/Control Panel. The ATS is also interfaced with the DCS.

INTEGRATED PLANT OPERATIONS

ELO 1.13 **DESCRIBE the following normal operating modes of the Standby Diesel Generator System:**

a. Manual

b. Automatic

Normal Operations

The Standby Diesel Generator sets are designed and controlled to start automatically on loss of normal site power to their respective MCC (7 or 8). The voltage regulation and frequency (speed) are automatically controlled by the equipment. Once rated voltage and frequency are reached, an ATS will transfer the output of the diesel generator to its MCC.

Once normal power is restored from the 480V unit substation for a period of 30 minutes, the ATS will transfer to the substation. The diesel generator set runs unloaded for approximately 5 minutes to cool down and then is automatically stopped.

In manual operation, voltage and frequency are again automatically controlled, but load is applied by the operator through the use of the Test Load Bank, which places a resistive load in steps of 50 or 100 kW on the diesel generator set.

System Alignment

First-time starting or following extensive maintenance/rebuild of the standby diesel generator sets, requires actions by Maintenance and Operations. The Maintenance portion includes such items as priming the Fuel System and priming the Lubrication System. Operator actions following the Maintenance portion include such items as verifying that the main fuel tanks and Diesel Fuel Oil Daytank are filled.

There are two (2) alignment modes for the diesel generator sets: Automatic Start Mode and Manual Start Mode.

Alignment for Automatic Start Mode

The alignment for automatic startup of D/G set No.1 will be performed in accordance with procedure 261-SOP-EEP-01, and the alignment of D/G set No.2 will be performed in accordance with procedure 261-SOP-EEP-02.

For proper alignment of the diesel generator set for automatic startup, the operator must ensure that necessary conditions exists (refer to procedure). Setpoints must be met, switches/breakers should be in the proper position, and all appropriate valves should be configured to specification to ensure accurate alignment. The DCS must also be configured per procedure.

The D/G valving should be aligned in the appropriate configuration for proper diesel operation. Proper alignment of the valves is also essential to prevent damage to system equipment when a startup is initiated.

The D/G Local Alarm/Control Panel contains indicator lamps that can burn out; therefore these items should be tested for reliability. To begin testing the indicator lamps, the power load bank No.2 switch located on the D/G Test Load Bank Control Panel should be in the OFF position. The indicating lights described in Table 2 should be pushed to ensure that the lamps are operational (see Table 2 and Figure 5).

The operator should ensure all control panel verifications have been made, and the DCS, valves and electrical components are aligned in accordance with the appropriate procedure. After a period of 30 minutes, the operator should ensure that the engine coolant heater and the lube oil heater are energized. This can be accomplished by reading a temperature increase on the water temperature gauge located on the Local Alarm/Control Panel.

To completely "set" the D/G in automatic start mode, the Engine Control Switch (ECS) located on the D/G Local Alarm/Control Panel, should be placed in the AUTO START position and verified by ensuring the D/G In Auto Start Mode indicator is illuminated.

Alignment for Manual Start Mode

The alignment for manual startup of D/G set No.1 will be performed in accordance with procedure 261-SOP-EEP-01, and the alignment of D/G set No.2 will be performed in accordance with procedure 261-SOP-EEP-02.

The alignment for manual start entails all of the elements described for the automatic startup alignment, except for placing the D/G in AUTO START. With the exception of the initial startup of CIF, the diesels will be aligned for automatic startup. Therefore, the alignment for manual startup will basically be a preparation for load testing of the sets.

The final step of the alignment for manual start mode is to record the run time of the engine. The run time can be read from the D/G Run Time Meter.

System Startup

There are two (2) basic system startups for the standby D/G sets: AUTOMATIC and MANUAL.

The automatic startup occurs when normal site power is interrupted. There are no operator-required actions for an automatic start to initiate, but operator surveillance of the sets is required.

Manual startup of the standby D/G set is usually performed for the purpose of testing the D/G set. Certain operator actions are required for the manual startup. Before starting the set, the operator should perform an alignment of the system as described in the *Manual Start And Load Test Of The Diesel Generator* section of the applicable SOP.

Due to the damaging effects of running an engine unloaded for extended periods, condensation and carbon buildup from running cool, the operator should be prepared to apply a minimum of 50 kW of load within five (5) minutes of startup. The actual mechanics of applying loads to the D/G set will be discussed later.

The operator will initiate a manual start by pushing the D/G start pushbutton switch located on the D/G Control Panel. The diesel engine, under prime conditions, should reach 1800 rpm and the generator output should be at 480V 10 seconds after startup. The engine operating speed can be determined by reading the D/G tachometer. The output voltage can be checked on all three phases (1-2, 2-3, 3-1) by rotating the D/G voltmeter switch to the appropriate position.

During manual operation of the D/G set, the operator should be aware of possible problem situations. Such situations may include a fuel supply leakage, an engine exhaust leakage, or a diesel trouble alarm. An appropriate response to these types of situations would be to stop the D/G set by pushing the D/G stop pushbutton. Various situations, which are described in the procedure, should be verified by the operator before applying a load.

Once the Standby Diesel Generator starts and all panel checks have been made, the set is ready for a load bank test.

Normal Operations

During normal operations, the standby D/G set is normally aligned and ready to start with the engine control switch placed in the AUTO START position. The pre-start checks have been completed, and rounds sheets are completed to document the D/G set condition. A loss of normal power to MCC 7 and/or 8 will initiate a D/G start. Plant loads essential for the shutdown/cooldown of the Rotary Kiln are automatically sequenced on, one at a time by the DCS. (See Table 7 *Diesel Loads*)Additional equipment fed from MCC 7 or 8 can be started by the operator as long as the D/G set output rating is not exceeded (350 kW at 526 amps). This indication is provided only at the D/G Local Alarm/Control Panel.

Sequenced Loads	Manual Loads
Quench Pump	HVAC Exhaust Fan
ID Fan	Rotary Kiln Drive
Scrubber Recirc. Pump	CAM Blowers
Service Water Pump	

Table 7 D/G Loads

Shutdown Following an Automatic Startup

The ATS will maintain the 480V feed to the appropriate MCC until normal power is restored. On sensing that the normal supply is available (greater than 90% voltage), a 30-minute delay timer actuates. This timer ensures that the available normal supply is stable. Should the normal supply degrade to less than 85% voltage during the 30-minute wait time, the timer resets and starts again. The ATS will automatically transfer to the available supply. When transferring, the ATS first checks the phase angle difference between incoming and running power sources to minimize inrush current and possible equipment damage. The ATS will transfer within six (6) to ten (10) cycles (0.1 to 0.17 seconds) and is a break-before-make device. A timer will allow the D/G to operate at no load (to allow for cooldown) for approximately five (5) minutes after the ATS transfers to normal power.

Following a shutdown of the D/G set from an automatic startup, the operators perform an inspection of the system. The following is a description of the various assurances that must be made:

- The DCS operator should verify that the D/G set is in the STANDBY mode noted by the Point Tag Display "D/G #1 STATUS".
- The daytank level should be above 3/8 full. This can be determined by utilizing the engine daytank level gauge located on the daytank.
- The engine oil level should be at the normal range. This can be determined by utilizing the D/G low oil level No.1 switch. If the level is low, the diesel engine requires API 15W-40 oil.
- The engine coolant level should be at normal range. This can be determined by utilizing the D/G low coolant level No.1 switch. If the level is low, the engine coolant is a 50% mixture of permanent antifreeze and water.

Shutdown Following a Manual Startup and Load Test

The D/G requires operator actions for a shutdown following a manual startup. Five (5) minutes after the diesel load has been reduced to zero, allowing time for both the D/G and the load bank to cooldown, the operator should stop the load bank No.1 blower by pushing the load bank No.1 blower STOP pushbutton. The Master Load bank No.1 switch and the Power switch should be placed in the OFF position. Then open the load bank transfer switch by pushing the TSOPB on the Local Alarm/Control Panel. The operator can now completely stop the diesel by pushing the D/G stop pushbutton(STPB).

Just as with the shutdown following an automatic startup, certain assurances must be made by the operator. These are as follows:

- The daytank level should be above 3/8 full. This can be determined by utilizing the engine daytank level gauge located on the daytank.
- The engine oil level should be at the normal range. This can be determined by utilizing the D/G low oil level No.1 switch. If the level is low, the diesel engine requires API 15W-40 oil.
- The engine coolant level should be at normal range. This can be determined by utilizing the D/G low coolant level No.1 switch. If the level is low, the engine coolant is a 50% mixture of permanent antifreeze and water.
- The DCS operator should verify that the "TROUBLE D/G #1" signal is not in alarm noted by the Point Tag Display "D/G #1 STATUS".

Once the above assurances have been confirmed, the operator can place the D/G set in automatic start mode by setting the D/G engine control switch to the AUTO START position and verify that the D/G In Auto Start Mode indicator is illuminated.

Test Load Bank Operation

An external Test Load Bank is provided for periodic surveillance testing of the D/G sets. The load bank consists of an outdoor enclosure (located north of each D/G enclosure) with groups of resistors that can be switched on to provide up to 400 kW of load for the D/G set. Each load bank is provided with a cooling fan and an air flow switch to ensure adequate cooling with the load bank in operation. A load bank transfer switch (outside north wall of the D/G enclosure) is provided to connect the D/G output to the local bank. The switch is controlled by pushbuttons (open/close) on the D/G Local Alarm/Control Panel. A load bank control panel, located on the east end of the D/G Local Alarm/Control Panel, is provided to operate the load bank. The D/G set is first started in manual start mode from the Local Alarm/Control Panel. Once the proper conditions are reached, the operator can begin the load bank test.

The periodic test is performed with the Engine Control Switch in the Manual Start position. Voltage and frequency are automatically controlled, but load is applied by the operator through the use of the Test Load Bank. Resistive loads are added in steps of 50 or 100kW on the D/G up to 350kW in full load test and 100kW in partial load test.

Abnormal Operations

Upset events involving the D/G sets will result in their failing to supply necessary backup 480V power to the MCC. Any D/G failure to start or trip once running will require a maintenance inspection to determine and correct the cause of the failure. No immediate recovery actions by the operator are possible.

A loss of power to MCC 7 or MCC 8 during a load test on the load bank will deenergize the respective load bank. The D/G will remain in operation and the ATS will transfer the MCC loads to the D/G in accordance with the order of the load sequencer. (See Table 7 *D/G Loads)*

Infrequent Operations

The D/G sets will normally be in STANDBY (auto start), or MANUAL for testing. The only anticipated infrequent operation would be a post-maintenance test. The extent of this test would vary depending on the scope of the maintenance performed. In most cases a normal Test Load Bank surveillance run, monitored by Maintenance personnel, would be required to prove the equipment is operable.

Summary

- The standby diesel generator sets have two operating modes, MANUAL and AUTOMATIC.

- The Manual Start Mode is used for D/G testing and the Automatic Start Mode is the normal operating mode.

- The standby diesel generator sets are designed and controlled to start automatically on loss of normal site power to their respective MCC. The voltage regulation and frequency (speed) are automatically controlled. Once rated voltage and frequency are reached, an ATS will transfer the output of the D/G to its MCC. Thirty (30) minutes after normal power is restored to the ATS, the ATS will restore normal power to the MCC. The diesel generator set runs unloaded for approximately 5 minutes to cool down and then is automatically stopped.